Unravelling life history of the Inland Freshwater Crab *Austrothelphusa transversa* in seasonal tropical river catchments

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ABSTRACT

Few freshwater aquatic species have ecological traits that deal with the vagaries of flow in ephemeral tropical rivers. In northern Australia, the tropical freshwater crab, *Austrothelphusa transversa* (von Martens, 1868) is a conspicuous species that occupies seasonal rivers, where it is thought to estivate in underground burrows while waiting for summer rain. During a survey in seasonal river catchments the first photographic evidence was obtained of an estivating female crab containing 42 crablets under the abdomen plate. Uncovering this female with crablets suggests that egg development progressing to crablets occurs during the dry season estivation when crabs are underground and no water exists in river channels; if this is the case then this female crab may have been waiting for rain, to emerge and successfully continue the life cycle in water. Since 2012 the southern Gulf of Carpentaria has experienced below average rainfall, contributing to no or short flow periods over most of the landscape. In light of modelled climate change (which predicts an increase in the number of years with low rainfall in northern Australia), along with intensification of agriculture development, it is postulated that reduced access to water might become a regular challenge for this crab species. With more data the IUCN Red List status (Least concern) for this species might need further review.

Key words: tropical rivers, waterholes, freshwater crabs, *Austrothelphusa transervsa*, water resource development, climate change, Australia

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Introduction

To understand how organisms function and interact in local environments ecologists develop and pursue field observations that contribute to testable ecological models (Chapman and Reiss 1992). These models contribute new data important in their own right in moving forward collective understanding and conservation (Dudgeon *et al.* 2006). A case in point are tropical river landscapes where the dry season breaks up connected rivers into a series of waterholes (in channel and off channel) that function as critical, and sometimes only, habitat for the survival of aquatic biota, especially fish. (Hurd *et al.* 2016; Datry *et al.* 2014; Jardine *et al.* 2012). The model in arid tropical regions is therefore that survival of aquatic species is dependent on the severity and duration of the dry season, which can be highly unreliable and characterised by brief, infrequent and episodic stream flow (McJannet *et al.* 2014; Karim *et al.* 2015), and whether waterholes last until the next wet season (Wallace *et al.* in press), when rivers again connect and enable fish to complete important lifecycle stages.

In addition to fish, freshwater crabs commonly occupy tropical and sub-tropical river catchments (Burggren and McMahon 1988). Globally, more than 7,000 species of brachyuran crabs are known (Ng *et al.* 1988; Yeo and Ng 1999), of which approximately 1,300 are considered freshwater species (Cumberlidge *et al.* 2009). Freshwater crabs have adopted freshwater, semi-terrestrial or terrestrial modes of life, and complete their life cycle independent of sea migration (Gratwicke 2004; Yeo *et al.* 2008; Devi *et al.* 2013). An estimate of global freshwater crab biodiversity suggests that a large number of species are yet to be described/discovered (Yeo *et al.* 2008). Cumberlidge *et al.* (2009) have undertaken a conservation assessment for the known freshwater crab species for the IUCN Red List, and note that two-thirds of species may be at risk of extinction owing to loss of habitat, predation, and contamination (see Butler and Marshall 1996; Reinecke *et al.* 2003; Dobson *et al.* 2007; Dalu *et al.* 2016). In these calculations, Cumberlidge *et al.* (2009) also point out that one in six species are already vulnerable to extinction, with 227 species classified as near threatened, vulnerable, endangered or critically endangered. For about half freshwater crab species (628 species) basic biology and ecology data is insufficient to adequately assess their future. In Australia, while seven species have been recorded (Davie 2002), a further 15 to 20 new species are yet to be described, most with distributions limited to small coastal catchments (P. Davie, Queensland Museum, Australia, personal communication). These species may be vulnerable to habitat decline and changes in water catchment hydrology; indeed they could be lost without knowing they exist.

Even for those described freshwater crabs in Australia, little is known on their ecology and biology (Davie 2012; Waltham *et al.* 2014). The Inland Freshwater Crab (*Austrothelphusa transervsa*) (von Martens, 1868) is probably the most widespread and has been the focal species in several studies (e.g., Greenaway and MacMillen 1978; Greenwaway 1980; Greenwaway *et al.* 1983a, b; Waltham *et al.* In review). It has an adapted strategy to deal with the ephemeral nature of the creeks in which it is found, digging holes into channel sides where it presumably (though not explicitly examined) lays quiescent until wet season flow (Davie 2012). This crab species is a K-strategist, having low fecundity (Davie 2012), and consequently there is little ability for widespread dispersal (N. Waltham unpublished data). This is a common trait in freshwater crab species elsewhere, and helps ensure local populations remain (Liu and Li 2000; Gratwicke 2004; Cumberlidge 2009). *A. transerva* is listed as 'least concern' in the IUCN Red List (http://www.iucnredlist.org/details/134922/0; accessed 19 September 2016) given its wide distribution, and because it is unlikely to be declining to qualify for listing in a more threatened category (Esser and Cumberlidge 2008).

Knowledge on the biology of Australia's most widespread freshwater crab *Austrothelphusa transversa* is based on data obtained from specimens collected in waterholes following wet season flow. To further unravel the life history of this crab species, specimens were dug from an ephemeral river channel in northern Queensland, where this crab is known to estivate during the dry season. Data presented here further adds to the understanding of this remarkable aquatic species occupying tropical river catchments of northern Australia.

Study area

Limnological surveys have been on-going for the past several decades (see TropWATER.com.au website) in ephemeral waterholes (that form in large river systems that become progressively disconnected during dry season; Wallace et al. 2015) in northern Australia to examine biological and ecological processes supporting aquatic productivity. Waltham et al. (2013) recently completed surveys in the Flinders and Gilbert River catchments (Figure 1a) in response to government plans to expand and intensify agricultural development in northern Australia. An important requirement of this proposed agricultural expansion will be access to water for irrigation, which effectively means harvesting water during summer wet season flow (Petheram et al. 2016). This is the same time that crabs emerge from their burrows to access waterholes (Davie 2012). Both of these catchments are large, have low relief (maximum elevation

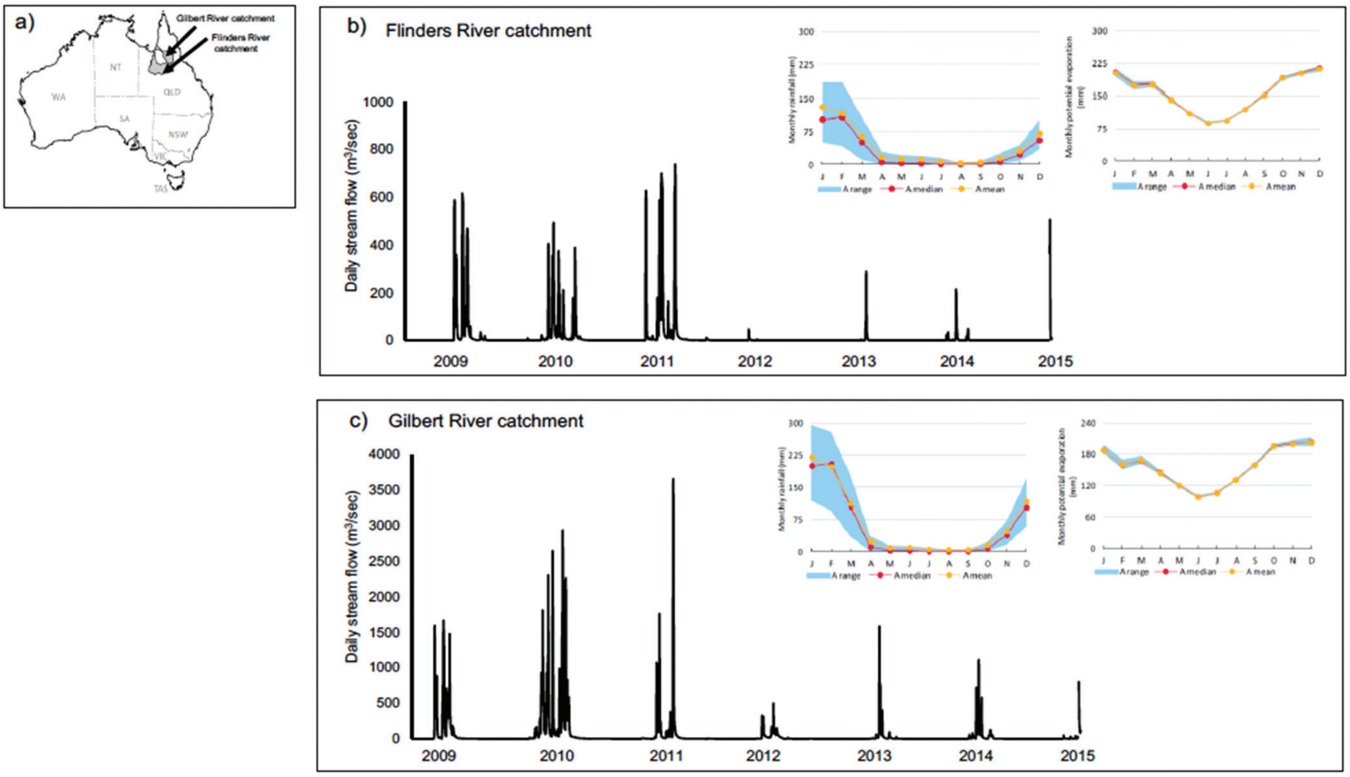


Fig 1. A) Location of Flinders and Gilbert River catchments in north Queensland, Australia. B) Monthly rainfall and areal potential evaporation averaged across the Flinders River; and C) Gilbert River catchments. (Annual range is the 20th to 80th percentile monthly rainfall and potential evaporation; reproduced from Petheram and Yang 2013).

~ 1,050 m) and areas of 109,000 km2 and 46,354 km2, respectively. The climate is semi-arid tropical with highly variable seasonal and annual rainfall (Petheram and Yang 2013). The Flinders catchment is drier, with a catchment annual rainfall average of 492 mm that varies from 800 mm near the coast to 350 mm in the south (Figure 1b), while the Gilbert catchment has a mean annual rainfall of 775 mm, which varies from 1,050 mm at the coast to 650 mm inland (Figure 1c). Evaporative demand is much greater than rainfall in both catchments at ~ 1,900 mm year-1 (Figure 1b). The seasonal rainfall produces unpredictable, highly variable river flow in both catchments, typically with peaks in January and February, followed by 6 to 7 months of little or no flow (May to November) (Figure 1b).

Methods

As part of a survey completed in December 2012 in the Flinders River catchment between 20 and 30 holes were excavated from several ephemeral creeks in the Dugald River catchment where there was evidence of crab burrows. From these holes, a small number of (8) crabs (*Austrothelphusa transversa*) were retrieved (3 males individuals; and 5 females individuals). Holes were approximately 0.6 m deep below the bank surface (Figure 2a and b).

Results and discussion

Among the crabs retrieved, the most interesting find was that a female (only a single individual among the five retrieved from burrows), positioned at the base of the hole between two boulders (each approximately 0.2 m diameter; Figure 2c) carried 42 crablets (~1 mm carapace width) that were freely crawling around her body (Figure 2d). This is the first account of this for any freshwater crab species in Australia. The strategy of estivation by ovigerous females has been recorded elsewhere (Lui and Li 2000), although in that study the authors noted that ovigerous females were in fact more commonly found on the forest floor beneath stones, timber and leaves, just a few metres adjacent to the stream, with females returning to the stream a few hours before hatching of the eggs.

In uncovering this female crab with crablets, my interpretation is that development of eggs in fertilised females, progressing to crablets, occurs whilst underground during the dry season. If this is the case, then this female crab may have been waiting for rain, to trigger surface

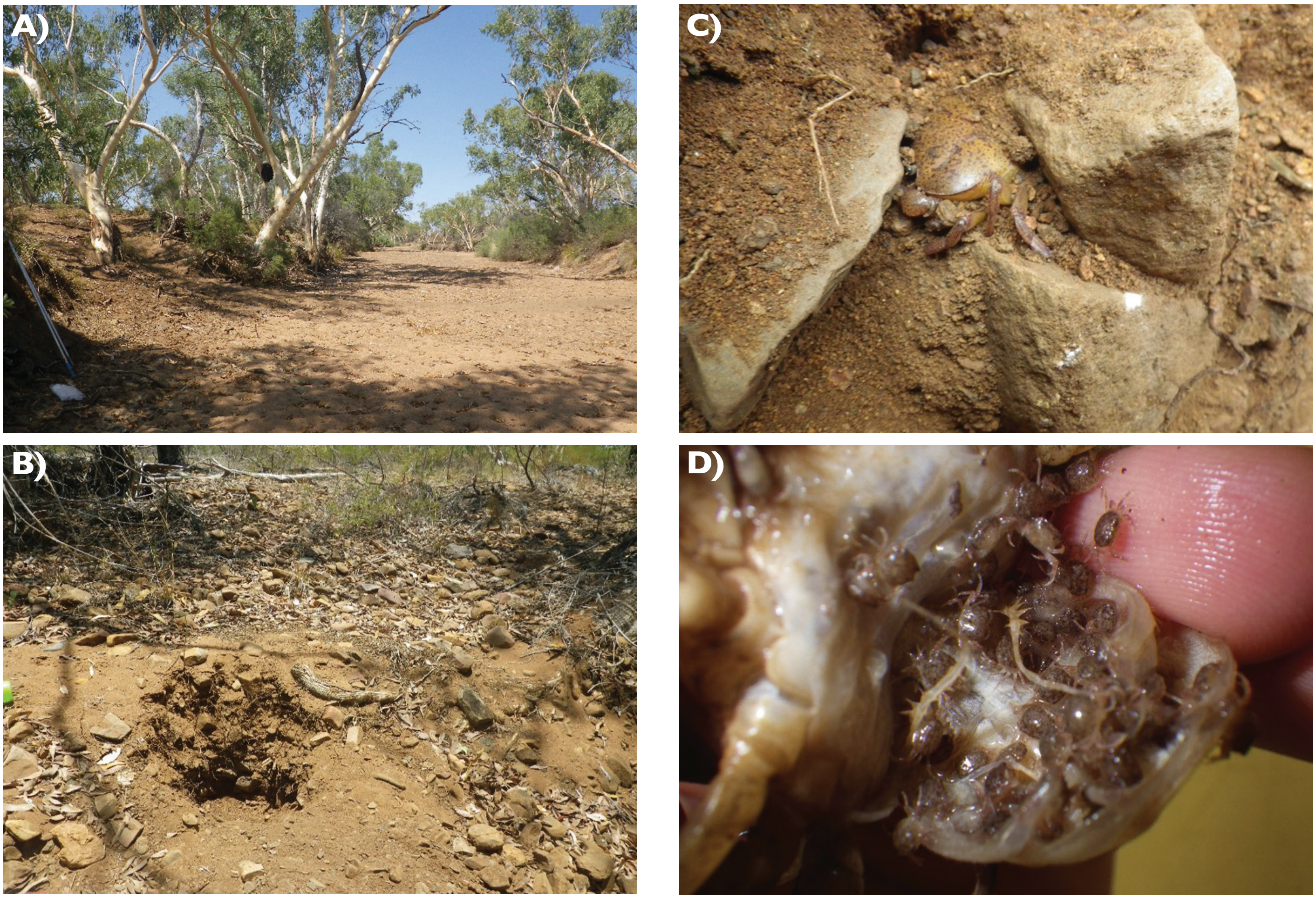
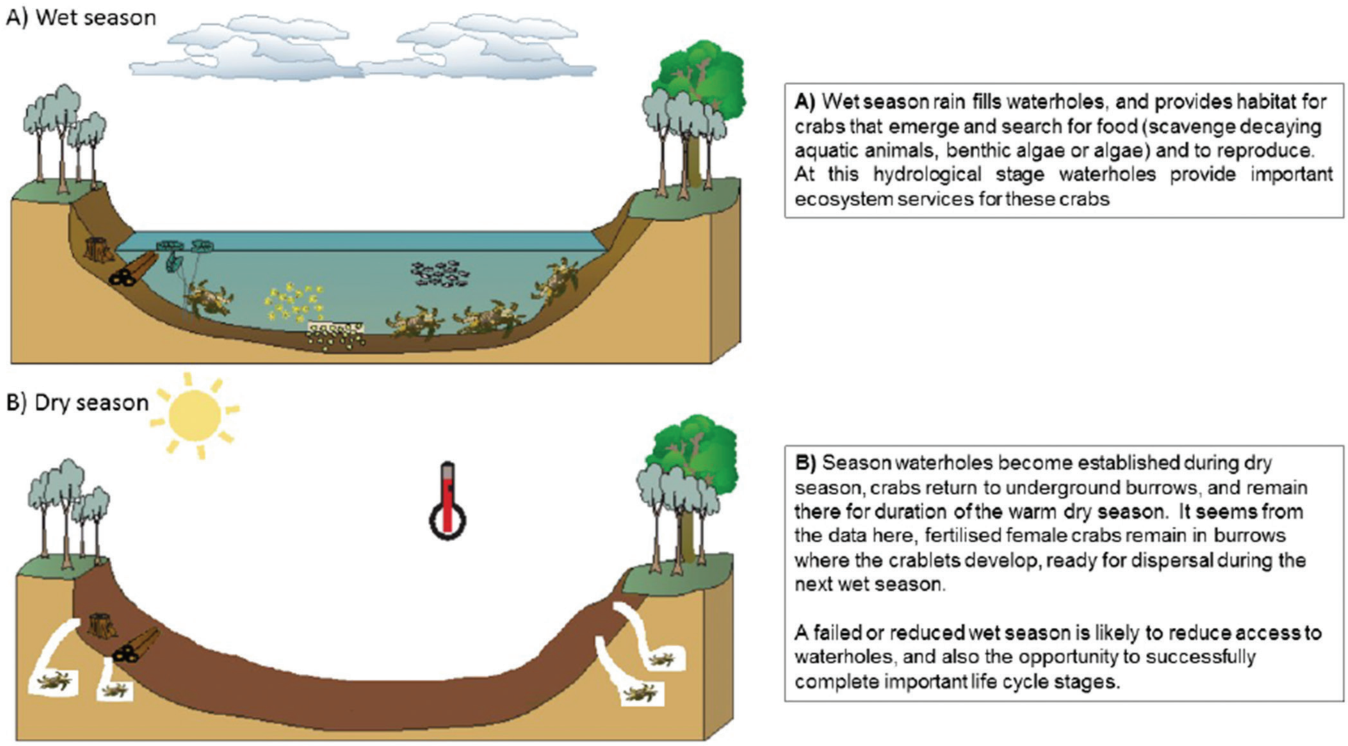


Fig 2. Ephemeral tributary of Flinders River, December 2012: A) dry season channel; B) hole dug in the channel bank; C) *Austrothelphusa transversa* (female) discovered in the hole, located at base of burrow between two boulders; and D) female crab with crablets under abdomen plate after removing from burrow.

emergence from the burrow occupied during the dry season. At some stage after reaching the newly formed waterhole, maternal care would presumably cease with crablets left to commence life in the waterhole. Some crayfish have a similar maternalistic strategy until the young depart and survive on their own (Kawai *et al.* 2015). An ovigerous female freshwater crayfish *Euastacus gumar* was also reported from a dry creek burrow in northern New South Wales (Coughran 2011). In the study on freshwater crabs in Taiwan, Liu and Li (2000) observed that females provided brief (approximately two weeks) post-hatching maternal care.

Accessing waterholes during the wet season for this Australian crab species is probably critical in completing the life cycle in two important ways. The first is that waterholes when available provide an important opportunity to seek food and to replenish energy reserves that have been diminished during dry season estivation (Figure 3a). The second is that waterholes likely assist (female) crabs to successfully reproduce, before retreating again to burrows as the local waterhole retracts (Figure 3b). If indeed waterholes are fundamental for these activities, then access, and maybe the duration of the access, during wet season becomes important in fulfilling critical life stages. In the time series data presented in Figure 1, it is possible that waterholes are more persistent during the higher rainfall years that occurred between 2009 and 2011. By comparison, completing this life cycle stage might be more challenging as a consequence of low or failed rainfall seasons, which have occurred since 2012 in both catchments, providing waterholes that may only persist for a short time (i.e., few days to weeks), or remain dry entirely (as was the case for the creeks examined in this study following a failed 2011/12 wet season; N. Waltham unpublished data). It is unknown whether ovigerous females would/could care for crablets in underground burrows beyond a single or a succession of failed wet seasons. Ostensibly, in a situation where a single or across a succession of failed wet seasons occur, such conditions may contribute to poor population recruitment in subsequent years.

Accessing water following flow in ephemeral regions of northern Australia is likely to be further hindered when considering future climate change expectations. In northern Australia the expectation is for more variable weather conditions in the future, specifically more frequent and extended dry periods (Petheram *et al.* 2012; James *et al.* 2013). For the Flinders and Gilbert River catchments (Petheram and Yang 2013), climate modelling predicts that the impact on mean annual rainfall change under the expected 2°C increase in global temperature relative to 1990, is not likely to be major in either catchment. However, the increased temperature is predicted to increase waterhole temperature up to 1°C (Wallace *et al.* 2015), which will increase acute thermal



A) Wet season rain fills waterholes, and provides habitat for crabs that emerge and search for food (scavenge decaying aquatic animals, benthic algae or algae) and to reproduce. At this hydrological stage waterholes provide important ecosystem services for these crabs

B) Season waterholes become established during dry season, crabs return to underground burrows, and remain there for duration of the warm dry season. It seems from the data here, fertilised female crabs remain in burrows where the crablets develop, ready for dispersal during the next wet season.

A failed or reduced wet season is likely to reduce access to waterholes, and also the opportunity to successfully complete important life cycle stages.

Fig 3. Proposed conceptual understanding of ephemeral waterhole in northern Australia. A) during wet seasons and rainfall, waterholes fill which contributes to important benthic and water column algae productivity, fish migrate, and the freshwater crab emerges from burrows to feed and reproduce. B) dry season waterholes retract completely, and freshwater crabs persist in underground burrows where they estivate (females complete egg and crablet development, before the next years' wet season rainfall). In some parts of the study areas, crabs may remain underground many years to survive through successive years of low or failed rainfall.

exposure risk for *A. transversa* (Waltham *et al.* in review). In addition to climate change, a more imminent threat to crab survival is increased and expanding agricultural development. Agricultural development expansion proposed for the Flinders and Gilbert Rivers reveal major implications on the timing and magnitude of wet season flow (Petheram *et al.* 2016). Given the vagaries in flow from one year to the next under future climate change predictions, coupled with increased agricultural development, failed or reduced wet season flow as seen over the past few years might become a common part of life for this crab species. More data are necessary to assess the ecological models proposed here, but the potential implications discussed may also be true for other freshwater crab species that are yet to be described in northern Australia. These additional data could be used to re-assess the IUCN Red List category, where this species might in fact be under emerging pressure, and therefore requires some level of protection.

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